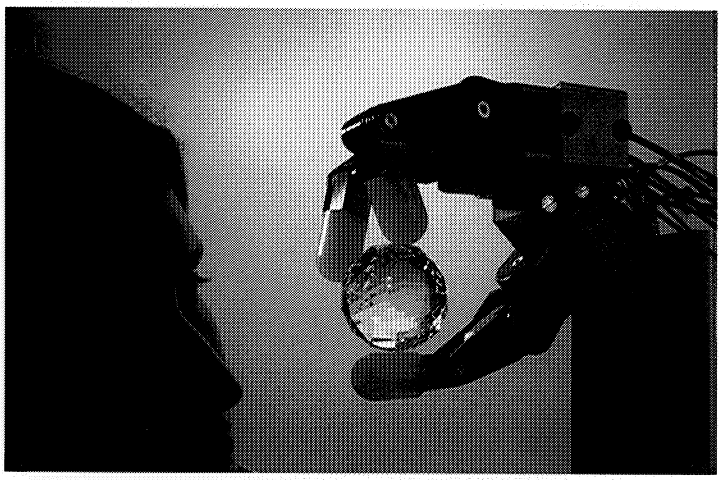
Although recent years have seen considerable advances in robotic systems technology, limitations are slowing broader use of robots in industry. A major limitation to the manipulative capability of a robot is the dexterity of the "hand," technically known as the end effector. Current hands have shortcomings in grasping objects; they are limited in the range of configurations the hand may assume and many types of robots must be fitted with special fingers for each object being handled. Robots are also limited in effecting precise position and force control. Attainment of true robot dexterity requires improvement in robot mechanisms coupled with advancements in robot control technology.

Beginning in 1982, NASA sought to promote such advancements, toward future use of dexterous telemanipulators in space or in industrial applications, by developing a test bed for research on control and utilization of dexterous robot hands. In cooperation with Stanford University and California Institute of Technology (Caltech), Jet Propulsion Laboratory (JPL) initiated development of an articulated hand capable of adapting its grasping posture to a wide variety of object shapes and of performing rapid, small motions required for delicate manipulation without need for moving the more massive arm joints. Initial specifications were drawn up by Carl Ruoff of JPL and Dr. Kenneth Salisbury, then with Stanford and now a research scientist with Massachusetts Institute of Technology's Artificial Intelligence laboratory. Later, Salisbury developed the final, detailed design.

The Stanford/JPL Hand, which has more recently come to be known as the Salisbury Hand, has three human-like fingers, each with three joints. The rounded tips of the fingers are covered with a resilient material that provides high friction for gripping. Like the fingers on a human hand, the robot hand fingers can provide more than three contact areas since more than one segment of each finger can contact an object. Thus, the robot hand can move objects about, twist them and otherwise manipulate them by finger motion alone. The hand can be adapted to different arms.



At MIT's Artificial Intelligence Laboratory, Salisbury has continued his work on the robot hand, concentrating on advanced software for commanding finger motion and interpreting information from fingertip sensors. The accompanying photo shows a National Bureau of Standards demonstration wherein the robot was commanded to explore the faceted crystal ball and construct a map of the object's shape, using input from finger-sensed contacts. It has successfully demonstrated that it can produce accurate representations of complex surfaces explored. Although real industrial application of such advanced robot hands is still some distance in the future, Salisbury feels that the JPL/Stanford/MIT work has provided a solid base for further exploration of the potential of dexterous robot hands.

In response to requests from other research groups for copies of the hand, Salisbury formed Salisbury Robotics, Inc., Palo Alto, California, to reproduce the device. In addition to the prototype, still in use in Stanford's Robotic Project, and another unit at MIT, copies have been delivered to General Motors Research Laboratory, the National Bureau of Standards, Sandia National Laboratories and the University of Massachusetts at Amherst. ▲